Burrowing Owl

Saskatchewan Burrowing Owl Recovery Project

A Synthesis of Research (1994-1998)

Fish and Wildlife Branch
Saskatchewan Environment and Resource Management

TransGas

Acknowledgments

In May 1996, four pipeline companies (TransCanada Pipelines, TransGas, Enbridge Pipelines Inc. and Foothills Pipe Lines) provided a significant financial contribution towards Burrowing Owl recovery in Saskatchewan. The contribution stimulated conservation (Nature Saskatchewan) and research partners (University of Saskatchewan and Saskatchewan Environment and Resource Management (SERM)) to unite with the pipeline companies in a three-year partnership agreement. Nature Saskatchewan delivers Operation Burrowing Owl (OBO), a voluntary private stewardship program for landowners with Burrowing Owls on their land, and the University of Saskatchewan and SERM were conducting research studies to determine factors responsible for the Burrowing Owl population decline. Funding from the pipeline companies constituted the major financial support required to continue and improve a series of studies that have provided information on the basic life history parameters as well as more specific information on factors that may be affecting the decline of one of Canada's most endangered species.

Along with the pipeline companies, many other agencies participated in the Saskatchewan Burrowing Owl Recovery Project by providing financial, administrative and logistical support. The long-term productivity project was facilitated through Ph.D. research conducted by Troy Wellicome of the University of Alberta. Wildlife Preservation Trust Canada (WPTC) provided significant financial and logistical support since joining recovery efforts in 1997. The Endangered Species Recovery Fund, a co-operative program of World Wildlife Fund Canada and the Canadian Wildlife Service of Environment Canada, provided support for Nature Saskatchewan's OBO program and for some of the research conducted under the Recovery Project. The Canadian Wildlife Service led investigations of the wintering grounds and SERM conducted a pilot study on migration in 1997 with funding support from North Dakota Game and Fish Department. The Owl Foundation and the Alberta Birds of Prey Centre provided captive-raised owls for research studies on release protocols. Funding was administered by Nature Saskatchewan, WPTC and the Saskatchewan Chapter of the Canadian Society of Environmental Biologists.

Job placement programs such as Environment Canada's Science Horizon's Program, the Canadian Council for Human Resources in the Environment Industry's International Environmental Youth Corps Program and the Human Resources Canada Summer Career Placement Program provided funding towards the salaries of the enthusiastic, highly qualified biologists and students who worked on the research studies and provided them with meaningful work experiences.

The Saskatchewan Burrowing Owl Interpretive Centre played a key role in raising awareness of the plight of the Burrowing Owl and in communicating results of the Recovery Project to the public.

Sincere appreciation and thanks are extended to the landowners who participated in the Recovery Project for maintaining nesting habitat and facilitating access to nest sites. Special thanks are extended to OBO participants for maintaining nesting habitat and participating in the annual Burrowing Owl census. Appreciation is accorded to all landowners who conserve and manage prairie to benefit Burrowing Owls and other prairie wildlife species.

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Executive Summary

Burrowing Owls (*Athene cunicularia*) were "uplisted" to the status of endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in 1995 and designated as endangered under Saskatchewan's species-at-risk provisions of *The Wildlife Act* in 1999. The status designations are based on population size and the rate at which the population was declining.

In 1987, Nature Saskatchewan's Operation Burrowing Owl (OBO) program began monitoring Burrowing Owl populations in Saskatchewan and Dr. P. James began surveying a portion of the current Regina Plain study area. Both data sets reported significant declines in Burrowing Owl populations within the same 12 year period.

Adult Burrowing Owls return to the Regina Plain from their wintering grounds between the second week of April and the third week of May. Males select a burrow and attempt to attract females by hooting, caching prey and modifying the burrow with dried horse and/or cow manure. Females begin laying eggs shortly after establishing a pair-bond with a male. Laying dates on the Regina Plain range from April 17th to June 8th. Clutch sizes range from six to 12 eggs and hatching begins 26 to 30 days after the first egg is layed. Females incubate the eggs and males provide food to the female and young. A variety of prey species are taken and diet appears to reflect prey availability. Small mammals are particularly important food items early in the year, with grasshoppers becoming an staple food source later in the season. Fledging occurs approximately five to six weeks after hatching when juveniles move to other burrows. Migration south begins as early as the third week of September and may continue until the end of October, however most birds depart by the second week of October. Many factors are suspected to contribute to the decline of Burrowing Owls in Canada. Mortality factors identified on the breeding grounds include predation by mammals, raptors and domestic dogs and cats, vehicle collisions, human interactions and starvation.

Research studies conducted from 1994 to 1998 under the Saskatchewan Burrowing Owl Recovery Project investigated specific factors affecting the Regina Plain Burrowing Owl population. Research conducted in 1992 and 1993 showed that supplemental feeding during the nesting period significantly increased the number of fledglings produced by owl pairs and a 1994 study revealed that the number of nests lost to predation was high. The Productivity Study, initiated in 1994, aimed to determine if the Burrowing Owl population decline could be halted or reversed by increasing productivity. We found that by using a combination of artificial nest boxes (ANBs) and supplemental feeding during the nesting period we could increase the number of young produced per nest (productivity). Properly installed ANBs virtually eliminate mammalian predation during the nesting period and nests provided with supplemental food (in the form of dead lab mice) fledged significantly more young than unfed nests in all years (except 1997 when a vole outbreak occurred across the prairies). However, increasing productivity with ANBs and supplemental feeding appears to be ineffective in halting or reversing the population decline on the study area.

In 1998, Burrowing Owl populations, both in and outside of the study area, increased for the first time since monitoring began. The population increase was attributed to the high vole populations experienced in 1997. The abundant food supply was likely responsible for increasing owl productivity, potentially increasing the overall fitness of adult and juvenile owls prior to migration and providing an alternate prey source for burrowing owl predators. Band observations confirmed an increase in the proportion of one-year old birds returning to the study area in 1998 as well as an increase in the number of (unbanded) owls which immigrated from other areas. The increased number of unbanded owls in 1998 suggests immigration may be vital to maintaining stable populations.

Adult survival on the breeding grounds until fledging was over 90 per cent. However, only about one-third of the adults banded on the study area returned each year, suggesting high post-fledging/overwinter mortality or that adult owls breed elsewhere in subsequent years. Band returns suggest that overwinter mortality rates for hatch-year owls (approximately 96 per cent) are substantially higher than those reported for adults (approximately 66 per cent). The Post Fledging Ecology Project provided valuable information on juvenile survival on the breeding grounds. In 1998, almost half of the radio-tagged juveniles died prior to migration, mostly due to avian predation. In contrast, avian predation was not cited as a factor contributing to juvenile mortality during the post-fledging period in 1997, when vole populations were high. Vehicle collisions are also considered to be a factor which contributes to juvenile (and adult) mortality on the breeding grounds. The Post Fledging Ecology Project also provided valuable information on juvenile dispersal and identified habitat fragmentation as a factor which may affect juvenile dispersal prior to migration.

A Migration Tracking Project was conducted in 1997 to increase knowledge of the migratory route of Burrowing Owls and to investigate migratory behaviour. Three relocations were detected in the Big Muddy Valley, Saskatchewan and two were detected near Dickinson, North Dakota. Owls departed from nest sites in the Moose Jaw area in a south-southeasterly direction, moved almost 200 kilometres per night, and used grazed pastures as stopover sites. Band combinations and radio-transmitter frequencies of owls monitored on the Regina Plain Study Area were provided to the Canadian Wildlife Service (CWS) to support research they were conducting in Texas and Mexico on identification of the wintering grounds. CWS reported the first winter band recovery of a Burrowing Owl banded in Canada (on the Regina Plain Study Area) from McAllen, Texas in 1997. In addition, CWS detected two possible transmitter signals in Texas and another from Mexico during investigations conducted in 1997 and 1998.

In 1997 and 1998, captive-raised, one-year old, Burrowing Owls were paired and released to assess the feasibility of such protocols should the need of such drastic measures be required in the future conservation of this species. Although some pairs successfully bred, their offspring did not survive as well as young produced by wild owls. Captive-raised owls also appeared to be more vulnerable to predation than wild owls and monitoring revealed some owls failed to migrate in the fall. No captive-raised adults or their young were observed on the study area in subsequent years. Releasing one-year old birds was deemed to be ineffective as a potential recovery strategy.

The Burrowing Owl Recovery Project was made possible through a partnership between government agencies, non-government organizations, universities, industry and landowners. Continued funding and logistical support will help to ensure Saskatchewan's role as leader in North America on Burrowing Owl conservation, research and recovery efforts is maintained. Multi-stakeholder partnerships will be a key factor in advancing recovery efforts on Burrowing Owls and other species at risk in the future.

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Introduction

In 1995, the Burrowing Owl (Athene cunicularia) was "uplisted" to the status of endangered species by the Committee on the Status of Endangered Wildlife. In 1999, the Burrowing Owl was designated as endangered under Saskatchewan's species-at-risk provisions of *The Wildlife Act*. This listing was based on its population size and the alarming rate at which the population was declining (Wellicome and Haug 1995). Conservative estimates suggest fewer than 1,000 pairs of owls returned to the Canadian prairies in 1998, including none in British Columbia and only a few reports of the species in Manitoba (**Figure 1**).

Many factors are suspected to have contributed to the decline of Burrowing Owls including: habitat loss, increased predator numbers, decreased food availability, natural range retraction, poor overwinter survival, pesticides and many other human related causes. In the past five years, extensive work has been conducted on Burrowing Owls on the Regina Plain in Saskatchewan. This report covers all of the basic and scientific information that has been gathered.

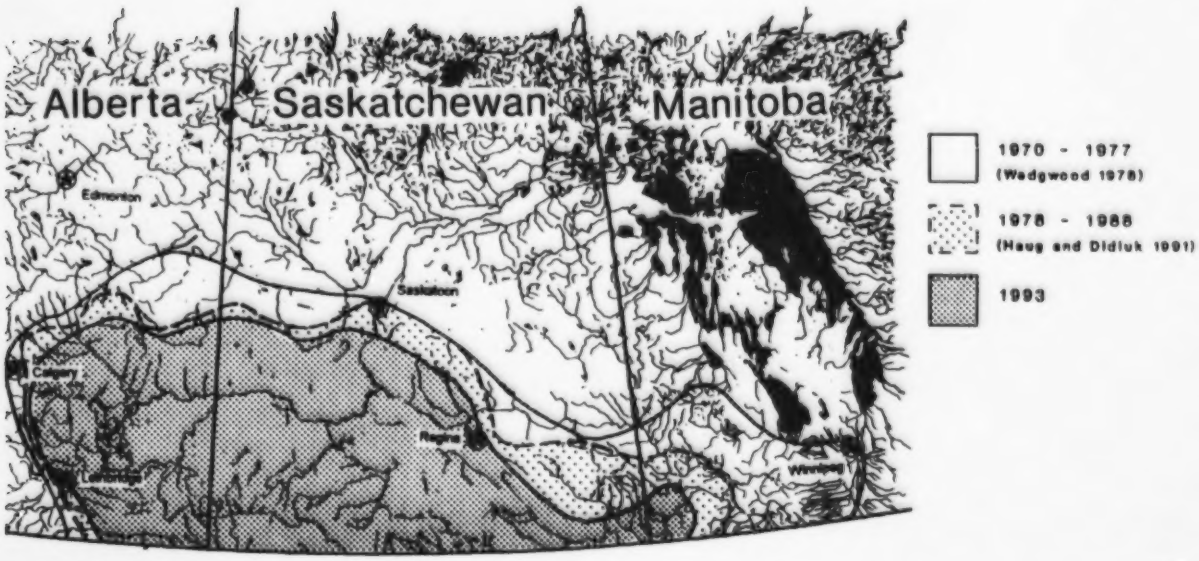


Figure 1. Recent range contraction of the Burrowing Owl in the Canadian prairies (modified from Wellicome & Haug 1990).

Study Area

The primary study area encompassed approximately 12,220 km² and was located in the Grassland Ecoregion of Saskatchewan (Harris et al. 1983), roughly bounded by the cities of Weyburn, Moose Jaw and Regina (**Figure 2**). The majority of this area lies on the Regina Plain with the southern-most portion extending into the Missouri Couteau. The entire area is intensively cultivated, with over 90 per cent of the original grasslands converted to cropland (James et al. 1990). Burrowing Owls rarely nest in cultivated areas. Consequently, owls nesting in our study area were limited to small patches of intensively-grazed pastures that were surrounded by a variety of cultivated habitats, including cereal crops, summer fallow and hayland. Most of these remnant patches of grassland were no larger than a quarter-section (800 m x 800 m) and there was usually several kilometres of cultivated land between grassland patches.

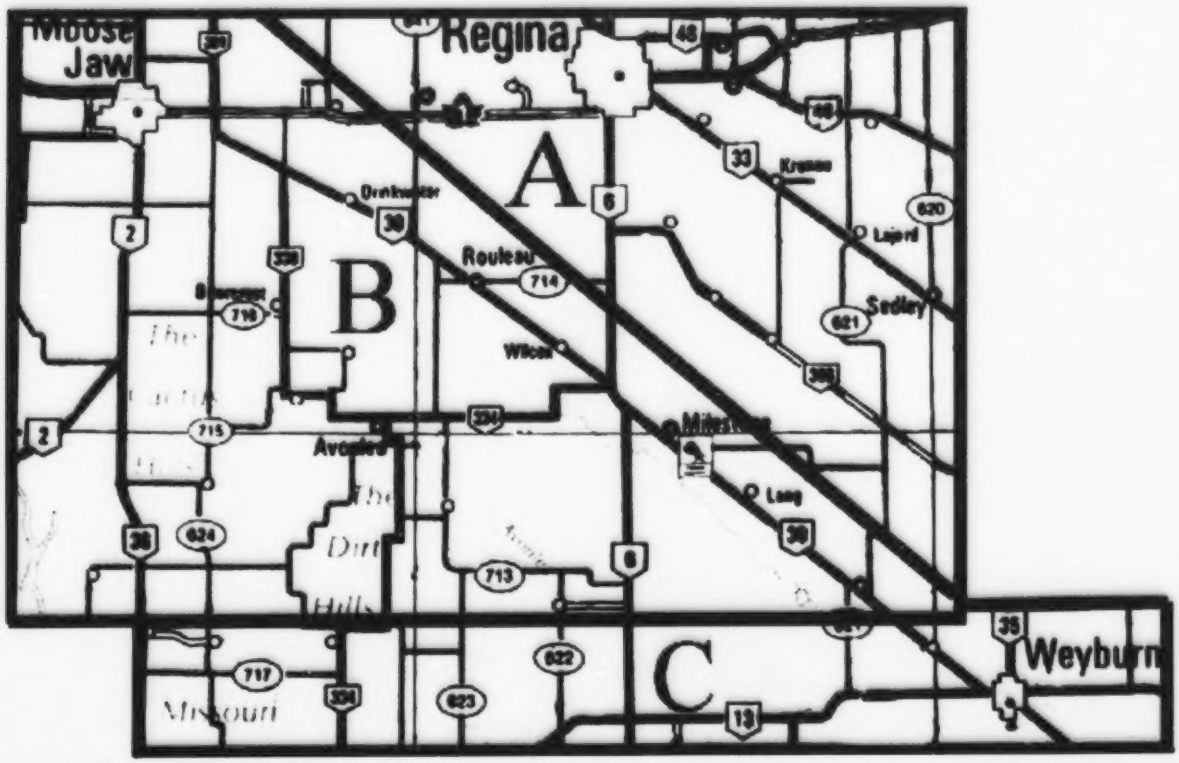


Figure 2. Study area on the Regina Plain. Area "A" surveyed by P. James since 1987, area "B" surveyed since 1994 and area "C" surveyed since 1996.

Objective

The overall objective of the studies conducted from 1994 to 1998 was to determine what factors may be contributing to the decline of Burrowing Owls across the Canadian prairies. To accomplish this goal, several studies were conducted to determine specific or proximate factors affecting the population. These studies included examining factors such as predation rates, food limitation on productivity, adult foraging strategies, juvenile dispersal and mortality, overall population dynamics, captive-release protocols and migration tracking. At the same time, information pertaining to the basic natural history of the species was collected including behaviour, reproductive biology, survival rates and foraging strategies. Combining the information gained on the natural history of the species with the information gathered through the specific studies has led to a better understanding of many factors that may be possibly affecting the Burrowing Owl population.

General Methods

Beginning in the third week of April in each study year, all Operation Burrowing Owl sites and other sites known to have had owls at least once in the previous five years were searched for nesting owls. Pastures were searched by driving or walking transects and all ground squirrel and badger burrows were examined for evidence of Burrowing Owl presence (white wash, feathers, manure and/or pellets). Landowners were contacted to ask if they were aware of the presence of any owls and if so to ask for permission to study the owls on their land. A few owls were also located with the help of Operation Burrowing Owl (which encourages the public to report owl sightings through the toll-free Hoot-line).

Once an active burrow was located and determined to be the eventual nest site, an artificial nest box (ANB) was installed to replace the natural nest burrow. The ANB consists of a length of six inch diameter weeping tile that serves as the tunnel leading into a wooden box that serves as the nest chamber (**Figure 3**). A series of buckets on top of the nest chamber allowed researchers easy access to the owl's nest while providing and maintaining all the attributes of the underground chamber in which the owls chose to nest. The easy access afforded by the ANB allowed the collection of invaluable information that could not have been collected in any other, non-destructive manner.

Nests were visited every three or four days to determine the date at which the first egg was laid in each nest, final clutch size of each nest, the hatch date for each egg and the fate of each chick within the brood. During nest-visits, all prey items stored inside of the nest were marked and counted in order to provide an estimate of food availability and diet. Each year, as part of the "Supplemental Feeding" experiment, several nests were provided with dead lab mice during each of the nest-visits.

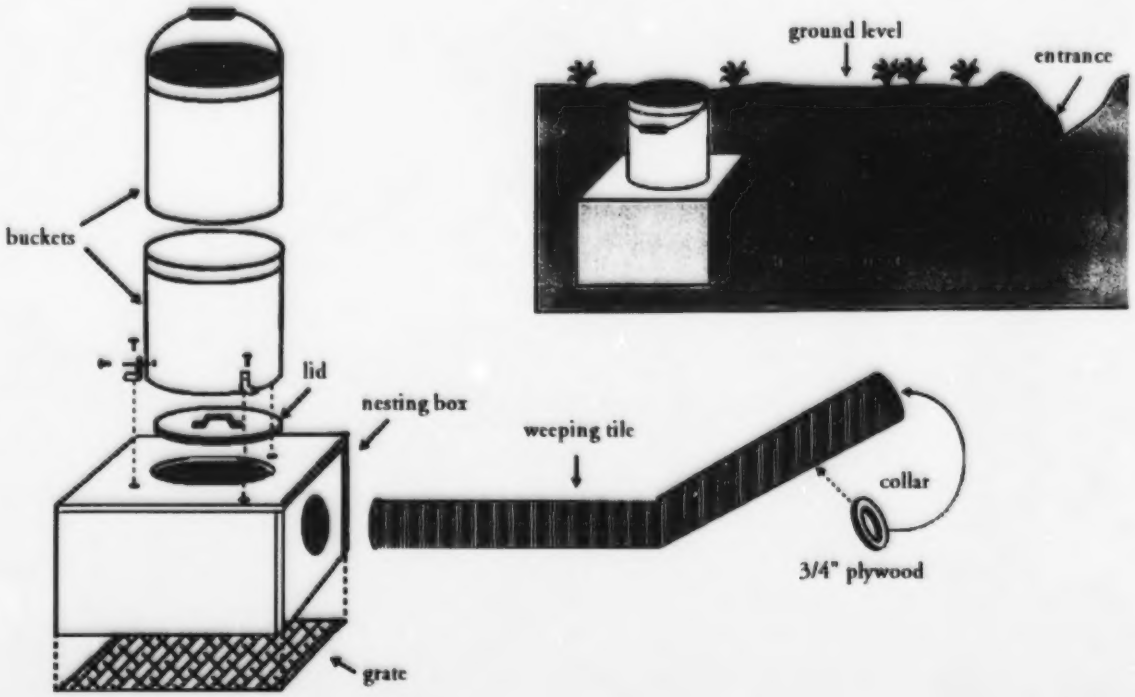


Figure 3. Schematic diagram of an artificial nest box.

Supplemental feeding began just prior to the first egg hatching in a nest and concluded when the youngest chick reached 41 days of age.

Throughout the course of each year, an attempt was made to capture and band all Burrowing Owls in the study area. Chicks were easily captured in the ANB and were banded when they were greater than 18 days old. Adult females were often captured inside the ANB during brooding and were banded. Adult females that were not captured in the ANB and adult males (which rarely enter the burrow) were captured with baited noose carpets on the mound outside of their nest burrow. All banded birds were given a United States Fish and Wildlife aluminum leg band and a unique combination of coloured plastic leg bands. All the young of the year were banded with a combination unique for that year and all individual adults were given a completely unique colour/aluminum combination. For example, in 1998, all young were banded with an aluminum band over a white band on the right leg (**Table 1**), one adult female in 1998 received the combination black over aluminum on the right and white over green on the left and no other birds in any year would have ever received that combination. Juveniles captured in subsequent years were and given unique band combinations so they never need to be captured again. The unique band combinations placed on adults provided researchers with an accurate visual determination of an individual without having to capture that individual again.

Field work usually concluded by the end of August in each year but radio-telemetry studies often extended until the time of fall migration (end of September).

General Biology

Spring Arrival

On the Regina Plain, adult Burrowing Owls returned from their wintering grounds as early as the second week of April, late arrivals extended into the third week of May and the average arrival date was the last week of April. It appeared males and females arrived at the same time but they did not arrive in established pairs. Males selected a burrow and attempted to attract females by hooting, caching food and lining the burrow with dried horse and/or cow manure, which is believed to be effective in reducing the effects of flooding.

Males hoot and hunt primarily at night (Haug & Oliphant 1990, Sissons et al. in press). The tunnel, nest chamber and mound area were often lined with dried manure, which was quite effective at keeping the nest dry during times of wet weather. Males stored prey items in the nest and often in a nearby burrow, presumably a measure of fitness to a prospective mate. Diet appeared to reflect prey availability. They kill just about anything small enough for them to capture and therefore the prey items in greatest abundance were most often found in the caches (T. Wellicome unpubl data, pers obs.). Early in the year, small mammals such as deer mice (*Peromyscus maniculatus*) and meadow voles (*Microtus pennsylvanicus*) were primary food items but prey caches also included songbirds, insects (especially beetles), frogs (*Pseudacris triseriata*), salamanders (*Ambistoma tigrinum*) and snakes (*Thamnophis radix*). Later in the year, they continued with the same diet but included grasshoppers as a staple.

Females actively searched for suitable males with which to nest, based on observations where females showed up at one male's burrow and left shortly thereafter, only to show up at a different male's burrow several kilometres away. This was also supported by observations of previously unknown females showing up at sites where captive-born males were released.

Breeding Biology

Females began laying eggs shortly after establishing a pair-bond with a male. The earliest laying-date was April 17th and the latest recorded laying date was June 8th. The average laying-date was approximately May 8th. Females laid one egg approximately every 36 hours until the clutch was complete and clutch sizes varied from six to 12 eggs. Clutch size was positively correlated with the date at which the first egg was laid but was not correlated with amount of food available to the female prior to egg-laying (Wellicome unpubl data). Average clutch size was approximately nine eggs per nest and on average 90 per cent of all eggs successfully hatched (Wellicome unpub data).

Females performed all of the incubating duties and incubation did not start until the first four or five eggs had been laid. Eggs hatched in 26 to 30 days depending on the number of eggs in the clutch (i.e. the more eggs the female had to incubate the longer it took for the first egg to hatch).

Table 1. Juvenile band combinations used in each year.

Year	Band Combination (Right Leg//Left Leg)
1994	— white // — aluminum
1995	— aluminum // — yellow
1996	yellow over aluminum // — —
1997	— — // white over aluminum
1998	aluminum over white // — —

Upon hatching, the young birds were completely dependent on their parents for warmth, food and protection. The adult female continued to do all of the brooding and the male provided the female and the young with all of their food. When weather conditions were poor and/or when food availability was low, the youngest chicks in the nest often died or were killed and eaten by their siblings or parents.

Late Summer/Early Autumn

Young birds first began leaving their nest in the second or third week of life. Usually, this involved short voyages to the mound immediately outside the nest but sometimes the brood was separated into two groups by their parents. One group would remain in the nest burrow and the other would be enticed to a nearby burrow. This undoubtably reduces the risk the entire brood would be lost in a single predation event. By the fifth and sixth weeks of life, the juvenile birds are hunting insects (mainly grasshoppers) on their own and are flying well. At the same time, the young birds leave their nest and take up residence in a different burrow, usually within a few 100 metres of their nest.

Causes of Mortality

Mortality factors of juvenile and adult Burrowing Owls include native predators such as badgers (*Taxidea taxus*), Northern Harriers (*Circus cyaneus*), Great-horned Owls (*Bubo virginianus*) and large hawks including Swainson's (*Buteo swainsoni*), Red-tailed (*B. jamaicensis*) and Ferruginous (*B. regalis*). Other losses are due to non-native predators including domestic dogs and cats, vehicle collisions, human interactions and starvation.

Migration

Migration south began as early as the third week of September and the vast majority of the owls have left the breeding grounds by the second week of October. An adult female was recorded on the breeding grounds at the end of October, long after the first heavy snowfall had come and gone and when night time temperatures were as low as -5 Celcius.

Productivity Project

A productivity study was undertaken in an attempt to determine 1) if the number of young produced per nest was affected by the amount of food available and 2) if the number of young produced per nest affected the overall owl population. The productivity study attempted to increase owl productivity through a combination of supplemental feeding and predator exclusion.

Artificial nest boxes (ANBs) effectively excluded most predators from Burrowing Owl nests. The diameter of the weeping tile tunnel and wooden collar was too small to allow badgers, foxes and skunks into the nest. Of the properly constructed ANBs, only two species of predators were recorded entering an owl's nest during the course of the study - a red fox (*Canis vulpes*) kit and weasels (*Mustela sp.*) (**Table 2**), despite several recorded attempts by badgers. Preventing predators from entering the nest resulted in significantly more successful nesting attempts on the study area in each year.

There have been no apparent negative affects of the ANBs. In many cases, owls readily chose previously installed ANBs when given a choice between natural burrows and artificial ones (**Table 3**). As in other years, owls readily choose artificial nest boxes (ANBs) as nesting burrows in 1998. Of the 52 nests that were discovered, 25 (48 per cent) were found in ANBs installed in previous years. At sites where nest boxes were available, 25 (78 per cent) of 32 nests were located in ANBs.

Table 2. Effectiveness of artificial nest boxes at preventing predators from destroying owl nests.

Year	ANB Nests	ANB Nests Depredated	Natural Nests	Natural Nests Depredated
1994 [A]	24	8		
1995	32	3 [B]	19	10
1996	31	0	16	3
1997	21	0	20	1
1998	33	1 [C]	10	4
Total	117	3 (2.6%)	65	18 (27.7%)

[A] The design of ANBs in 1994 did not include a metal grate on the bottom. Eight nests were lost to badgers that dug under the box and into the nest. These data are excluded from the totals.

[B] Two nests were lost due to badgers filling in the burrow with dirt while trying to enter the ANB. The other nest was lost to a red fox kit small enough to bypass the collar.

[C] One nest was lost as a result of a badger. This ANB did not have a wooden collar and is excluded from the totals.

The supplemental feeding experiment involved providing food to owl nests and measuring the number of fledged young from those nests. Owl pairs that successfully hatched young were provided with supplemental food for between 40 and 50 days after first hatch. Each nest was fed at three day intervals by leaving dead lab mice and/or quail at the nest burrow's entrance. Nests were provided with 85 grams of food per day (255 grams/three-day interval), which corresponds to three times the daily requirement of an adult Burrowing Owl in captivity (Marti 1973). The number of young were counted 41-days post-hatching and were considered to be fledged.

Since 1992, supplemental feeding has been taking place on the study area. In 1992, 1993, 1996, 1997 and 1998 several nests were not provided with supplemental food and these served as controls. In 1994 and 1995, all nests received supplemental food in an attempt to increase the overall owl population. For statistical purposes, nests were alternately assigned as "treatment" or "control" based on their clutch size and laying date. Only those nests initiated in artificial nest boxes were included (nests in natural burrows present problems in consistency and accuracy of results).

There was a statistically significant difference in the number of fledged young between "control nests" and "fed nests" in all years except 1997 (**Figure 4**). In 1997, it should be noted there was a very high meadow vole population across the prairies. Burrowing Owls were likely able to provide a maximum amount of food to their young, regardless of the supplemental food (**Figure 5**). Excluding 1997, pairs fed supplemental food during the nestling period fledged 17 per cent to 190 per cent more offspring than control nests. This data suggests food availability limits overall productivity and leads to the question of whether productivity limits the Burrowing Owl population.

Table 3. Per cent of owls naturally selecting artificial nest boxes over natural burrows.

Year	Per Cent of Nests in ANB
1994	48
1995	60
1996	59
1997	47
1998	48

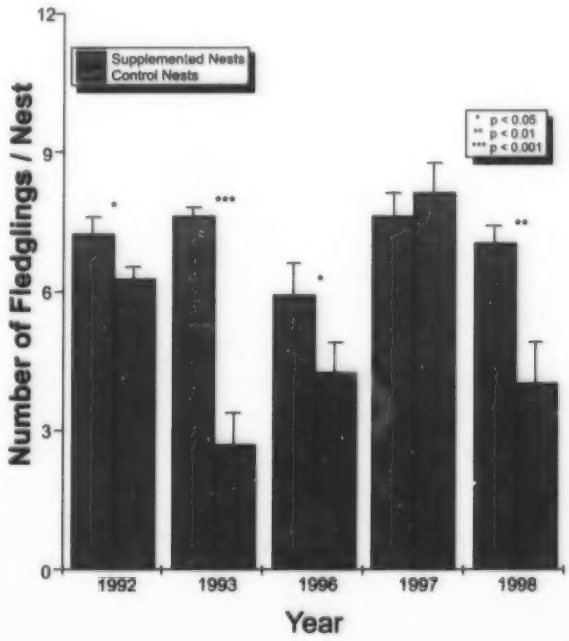


Figure 4. Comparison of fed versus unfed nests.

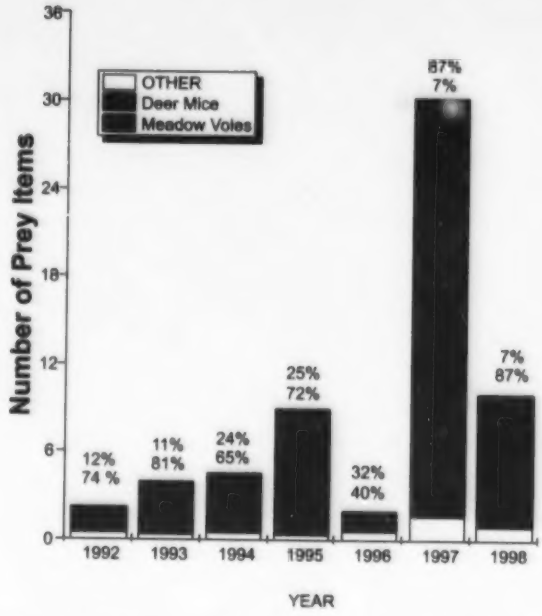


Figure 5. Mean prey caches in Burrowing Owl nests before egg laying.

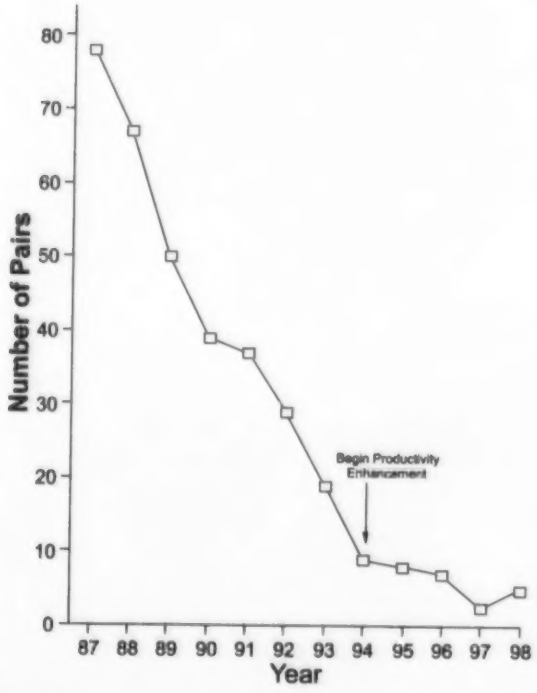


Figure 6. Burrowing Owl population in section "A" of the study area (1987 to 1993 provided by P. James).

Population Dynamics

Dr. P. James began surveying a portion of the study area for Burrowing Owls in 1987 (James et al. 1996). Because his area was encompassed within this project's study area, a comparison of the population decline rate prior to and during this study was possible. Although the area's habitat structure has not dramatically changed in the past 12 years, the Burrowing Owl population has plummeted over this period (**Figure 6**). A similar trend was found in the number of owl pairs reported by Operation Burrowing Owl members over the same time period (**Figure 7**; Skeel et al in press). The number of owl pairs declined 88.5 per cent over seven years prior to the productivity enhancement study (average = 12.7 per cent per year) and declined another 44 per cent in the four years following productivity enhancement (average = 11 per cent per year). It should be noted the actual number of owls present over the past five years was low and a decline of even a single nest between years translates into a large percentage of loss. Regardless, these data suggest productivity enhancement is not stemming the decline of the Burrowing Owl population.

The population does appear to show signs of stabilization since 1994 but this is at a dangerously low population size. In 1997, there were only five owls found and had there not been a population increase in 1998, the population would have approached zero. However, there was an obvious increase in the owl population across the entire study area following the year of high vole population (**Figure 8**). This was contrary to the results of the productivity enhancement study but there were some key differences between the natural food high and the supplemental feeding experiment. Not only did the voles provide ample food for the owls during brood-rearing but they likely provided sufficient food supplies to increase the overall condition of young birds before migration.

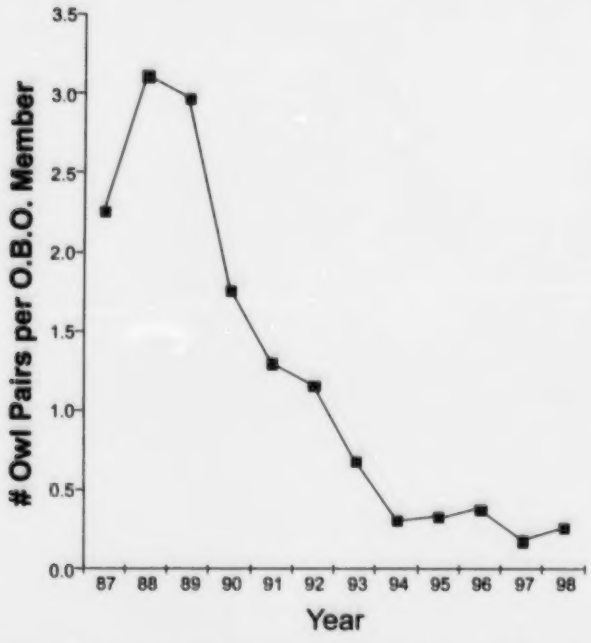


Figure 7. Number of pairs of Burrowing Owls reported per Operation Burrowing Owl member (Skeel et al. in press).

Figure 8. Number of Burrowing Owls found on sites within the study area searched in all five years of the study.

This hypothesis was supported in 1998 when there was an increase in the proportion of one-year old birds returning to the study area (**Figure 9**). Not only was there an increase in the number of young produced in 1997 but a greater proportion of those young returned to breed in the area the next year.

Another hypothesis was a greater post-fledging/pre-migratory survival rate. This argument is supported by the evidence of significantly more avian predators during the high vole year (Poulin et al. in press) but a very low rate of predation on juvenile owls. This was likely a result of an alternative prey source for predators - so many voles for the other raptors to capture, the need to expand their effort to try and capture Burrowing Owls was probably unnecessary.

Another hypothesis is that because the vole outbreak was not isolated to the study area, an increased prey base outside the study area would have increased Burrowing Owl productivity at a far greater scale than this study examined. Evidence for this hypothesis was provided by the increased return rate of unbanded birds on the study area the year after the vole outbreak (**Figure 10**). Because nearly all of the birds on the study area were banded before they migrated south each winter (**Table 4**), most of the unbanded owls discovered in the study area the following year had to be immigrants from areas outside the study area. An interesting trend arises when comparing the study areas's overall owl population to the number of unbanded birds returning in the spring (**Figure 11**). These data suggest immigration may be vital to maintaining a stable population. This would also help explain why productivity enhancement did not influence the population on the study area because in order to increase the population on the study area, adjacent areas would have also had to produce more owls. A closer look at the data suggests a lack of male immigration may be driving the population in a

negative direction. In 1997, a year with a drastic population decline, there were noticeably fewer unbanded males on the study area (**Figure 12**).

Dispersal and Mortality

Adult survival appears to be very high on the breeding grounds (**Table 5**). Of the 782 adults known on the study area since 1992, only 29 (3.7 per cent, range 0.7 to 6.8 per cent per year) have been killed before migration (mean = 4.43 per cent of females, 3.02 per cent of males). The majority of these deaths (79 per cent) occurred because of predators. However, overwinter mortality is considerably higher. Of the 70 adults banded in 1996, only 22 (31 per cent) were recovered in subsequent years and of the 52 banded in 1997, only 18 (35 per cent) were recovered in 1998. Although the sample size is small, these data suggest that only about one of three adult owls return to the breeding grounds after fall migration.

Juvenile survival is considerably poorer. Since 1986, 1702 juvenile owls have been banded and 74 (mean = 4.34 per cent, range zero to 8.22 per cent) of those birds were observed in subsequent years (**Table 6**). This suggests overwinter mortality rates for hatch-year Burrowing Owls on the Regina Plain approaches 95 per cent.

Another possibility is that the birds leaving the breeding grounds in the fall were returning to a different area (not the study area) in the spring. This was partially supported by the difference in return rates of adult males versus adult females (**Figure 13**). Each year, at least as many adult females were banded on the study area as males and in two of three years more females were banded than males. This was likely a result of the relative ease with which females were captured in the artificial nest boxes compared to the extensive effort required to trap males with noose carpets. Regardless, in every year more banded males returned to the breeding grounds than banded

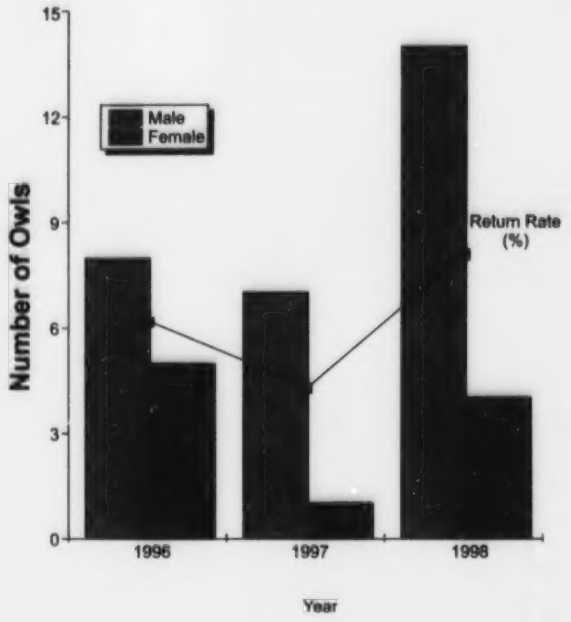


Figure 9. Number and proportion of one-year old birds returning to the study area.

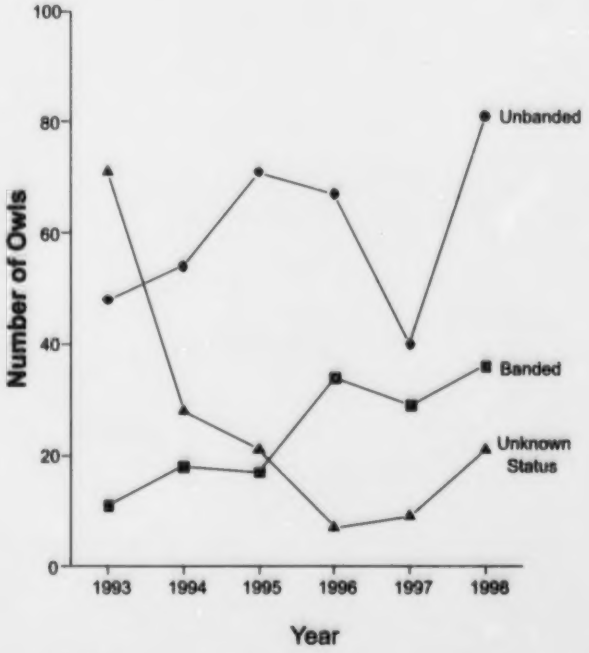


Figure 10. Band status of birds returning the study area each year.

Table 4. Per cent proportion of owls in the study area that received leg bands in each year.

Year	Adult Male	Adult Female	Juveniles
1994	42	42	67
1995	27	51	87
1996	63	87	88
1997	76	76	83
1998	62	74	80

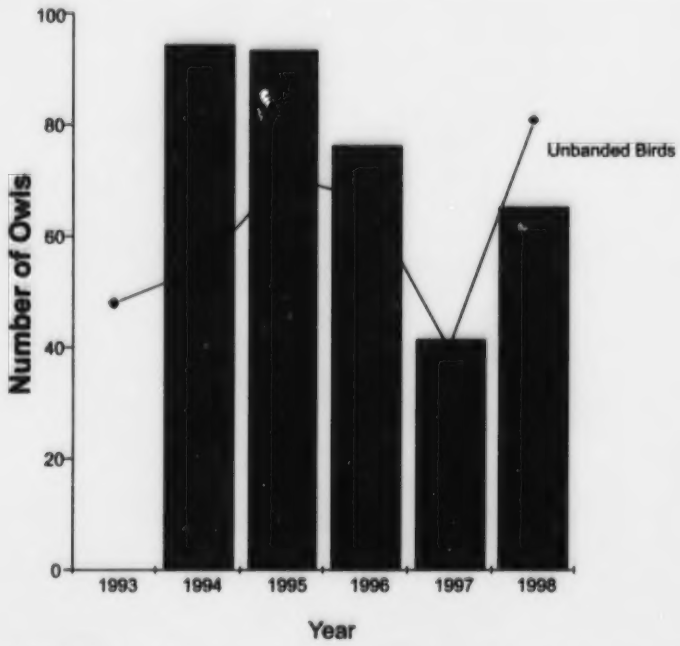


Figure 11. Population of owls versus the number of unbanded owls returning to the study area.

females. There is no reason to believe adult females have a significantly higher mortality rate than males, therefore, this suggests males had a higher site fidelity and females disperse farther between years. This is supported by the dispersal data collected on adults observed in two consecutive years (**Figure 14**). Only one of 35 (2.9 per cent) adult males observed nesting in one year was observed farther than one kilometre from this original nest site in a subsequent year. However, 13 of 36 (36 per cent) adult females were observed farther than one kilometre from the site they nested in the previous year(s).

Juvenile Burrowing Owls also showed a sex difference in their natal dispersal patterns (**Figure 15**). Sixteen of 35 (46 per cent) male owls banded as juveniles were observed within one kilometre of their natal nest in subsequent years and only four of 21 (19 per cent) females showed the same pattern. However, 21 of 35 (60 per cent) males returned to within five kilometres of their natal nest and 14 of 21 (66 per cent) of females returned to within this same proximity. But, three of 21 (14 per cent) females were recovered farther than 95 kilometres from their natal nest and there were 14 fewer females recovered than males over the course of this study. Because there is no reason to believe females

Table 6. Survival rates (percentage) of adult owls on the breeding grounds. (Wellicome unpub. data)

Year	Number of Males	Number of Male Deaths	Male Survival Rate	Number of Females	Number of Female Deaths	Female Survival Rate
1992	68	2	97	69	5	93
1993	68	0	100	68	1	99
1994	50	2	96	50	0	100
1995	52	1	98	51	6	88
1996	54	3	94	52	4	92
1997	32	1	97	30	0	100
1998	74	3	96	64	1	98

had a higher mortality rate, it is likely that at least some of the females were not returning to our study area.

Post Fledgling Ecology Project

In 1997 and 1998, a pilot study was conducted to determine the dispersal patterns of juvenile Burrowing Owls after they left the nest and before they left for fall migration (Todd in press). This involved putting necklace style radio-transmitters on chicks that were 25 to 35 days old and monitoring their locations every other day until they migrated south for the winter. Although some sites had more than one nest, only one chick per nest received a transmitter in order to maintain some measure of independent samples.

Three basic patterns of dispersal emerged. Fourteen of 30 (47 per cent) juveniles that received transmitters stayed at their nest for the duration of the summer, making only small movements away from their natal burrow but always returned to the nest in a few days. Four of 30 (13 per cent) juveniles dispersed to a single "satellite burrow" within a short distance of their nest and remained there for the duration of the summer. Occasionally, these birds would make short distance movements away from this burrow but always returned to it and not their natal nest burrow. Twelve of 30 (40 per cent) of juveniles dispersed in a "multiple burrow" fashion. They moved successively farther and farther from their natal nest, choosing a new burrow each time. They remained at each burrow for several days before moving on to the next burrow. This type of dispersal pattern has been documented as the "normal" dispersal pattern for Burrowing Owls nesting in large prairie expanses. Because less than half of the juvenile owls on the study site dispersed in a "normal" manner, there is reason to believe habitat fragmentation may be affecting their dispersal behaviour. For this reason, work will be continuing in this area.

Table 6. Return rates of juvenile owls banded on the study area since 1986 (P. James unpubl. data; Wellicome unpubl. data).

Year	Number of Fledglings Banded	Number Returned in Subsequent Years	Return Rate %
1986	65	3	4.62
1987	122	6	4.92
1988	128	6	4.69
1989	92	4	4.35
1990	38	1	2.63
1991	76	6	7.89
1992	131	4	3.05
1993	293	3	1.02
1994	145	7	4.83
1995	208	11	5.29
1996	185	5	2.70
1997	219	18	8.22

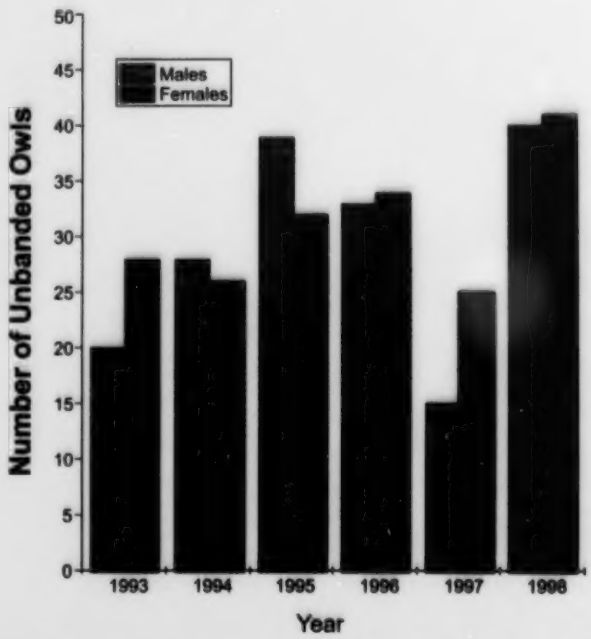


Figure 12. Number of male and female unbanded owls returning to the study area each year.

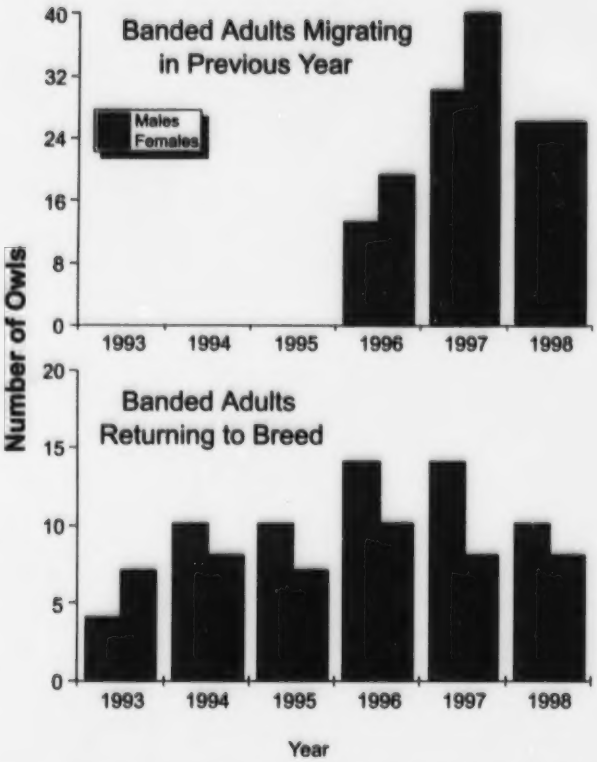


Figure 13. Comparison between the number of male and female adults banded each year versus the number of banded male and female adults returning to breed in subsequent years.

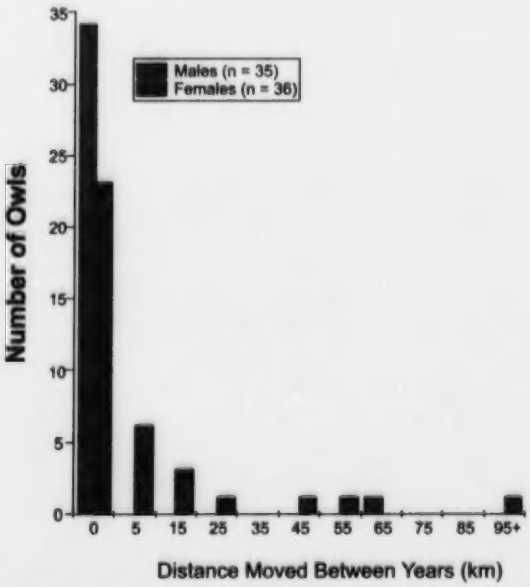


Figure 14. Frequency distribution of adult dispersal distances (the distance between the location an owl was observed in one year and the location it was observed in a subsequent year).

Factors causing mortality of juvenile owls and the rate at which owls died before migration was another important facet of Burrowing Owl ecology and this was studied simultaneously with the dispersal study (Todd in press). In 1997, zero of 12 radio-tagged juvenile owls died before migration. This is an unusually low rate considering there were so many hawks in the area in 1997 (Poulin et al. in press). In 1998, 15 of 33 (45 per cent) juveniles owls with transmitters died before migration (**Table 7**). Seven (47 per cent of deaths, 21 per cent of owls) of these deaths were due to avian (Red-tailed, Swainson's and Ferruginous Hawks and Northern Harriers as well as Great-horned Owls are common in the area) predation. Two of the seven avian predation deaths occurred in one pasture, in which there were also several non-radio tagged Burrowing Owls killed by raptors. Of the six nests located in this quarter section, two adult males were killed by hawks, an adult female was killed by a Great-horned Owl and at least six non-radio tagged juveniles were killed by hawks. A Great-horned Owl nest was in this quarter-section and Ferruginous, Swainson's and Red-tailed hawks were almost always present in the area. This may suggest that locally high predation rates may be associated with proximity to hawk nests.

Casual observations by researchers and reports from OBO Landowners suggest that vehicle collisions are responsible for a higher number of mortalities than are reflected by the results of this study.

Male Foraging Project

In 1997, a male foraging study was initiated to determine basic hunting information and to determine what habitat types might be important for hunting grounds (Sissons et al. in press). To gather this information, necklace style radio-transmitters were placed on adult male Burrowing Owls from early-to-mid June and removed when young had fledged from the nest, at which time food demands were likely at their highest point of the year. Each

night, beginning at sunset and concluding at sunrise, owl locations were recorded by a triangulation method between two observers with radio-receivers (one point per owl per hour). Habitat being used by the owl(s) was measured at the end of the tracking season and home range sizes were calculated with a 95 per cent minimum convex polygon method.

To date, only one other study has examined foraging behaviour (Haug & Oliphant 1990). Haug and Oliphant found Burrowing Owls near Saskatoon used grass-forb areas for hunting and avoided croplands and grazed pastures. Mean home-range size was 2.41 km2 (n = 6; range 0.14 - 4.8 km2) and peak foraging activity occurred between 2030 and 0630 hours. Sissons et al. found the home ranges were substantially smaller on the Regina Plain in 1997 (n = 4; mean 0.35 km2, range 0.08 - 0.49 km2). It was likely the owls in 1997 did not have to travel as far to hunt because of the area's over-abundance of voles. This suggests owls adjust their foraging patterns based on prey abundance and availability.

Migration Tracking Project and Wintering Grounds Investigations

Information on the location of the Burrowing Owl's wintering grounds and the migration flight-path is scarce. As of 1997, of the more than 3,000 owls banded in Canada, only nine banded owls had been recovered outside of Canada. Recoveries from owls banded in Saskatchewan and Manitoba had been reported from Colorado, Oklahoma, Nebraska, Louisiana and Texas. These recoveries were reported during April, September and October, presumably while owls were migrating.

To improve knowledge, radio-transmitters were placed on Burrowing Owls in the Moose Jaw, Saskatchewan area before they departed in the fall of 1997. The owls were tracked from an airplane during their migration south (Clayton

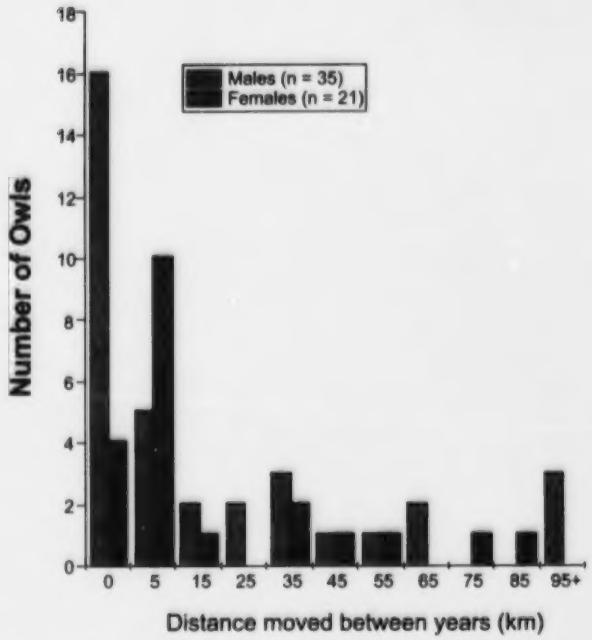


Figure 15. Frequency distribution of juvenile dispersal distances (the distance between an owl's natal burrow and the location that owl was observed in a subsequent year).

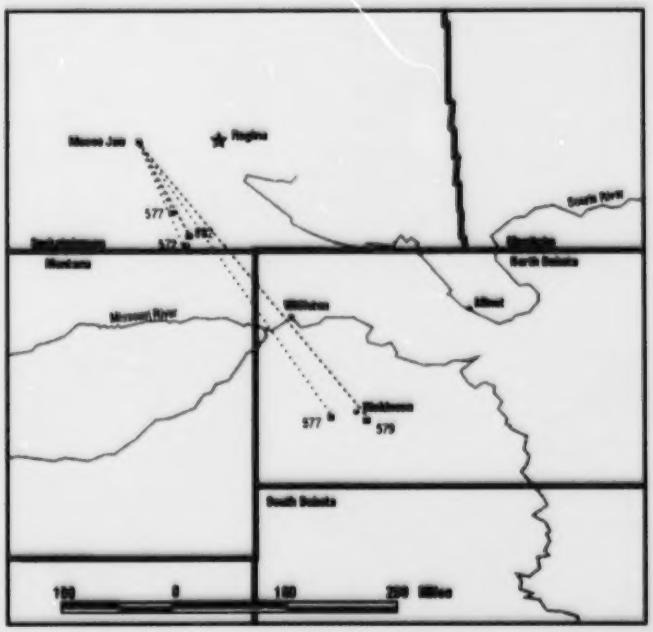


Figure 16. Location of Burrowing Owls during fall migration. Numbers next to location indicate transmitter frequency.

1997). A field crew on the ground relayed information to the aircrew when an owl departed during the night. The following day, the aircrew began searching for the signal by flying transects over large areas. The signals were picked up from as far away as 21 kilometers from 5,000 feet of altitude off either side of the aircraft. Coordinates provided from radio signals recorded from the air were then relayed to the ground crew to obtain a more detailed location of the owl. Because owls departed around sunset and flights could only be conducted after sunrise, tracking success was compromised when bad whether moved in during the night.

Of the 11 owls that successfully began migration with functioning transmitters, there were five relocations on the migration route (Figure 16). Three owls were located in southern Saskatchewan near the Big Muddy Valley on October 4th, the day after they departed Moose Jaw. Two owls were located near Dickinson, North Dakota on October 6th, one of these was possibly one of the owls found in the Big Muddy Valley two days earlier.

In general, owls departed Moose Jaw in a south-southeasterly direction. They migrated at night but did not necessarily fly every night. Nightly movements averaged 186 kilometers ($n = 4$; range = 109 - 326 km) and the areas serving as stopover sites were comprised of grazed native pastures, similar to nesting habitat on the Regina Plain.

Transmitter frequencies and leg band combinations of owls monitored in Saskatchewan and Alberta were provided to the Canadian Wildlife Service (CWS) to support efforts aimed at locating the wintering grounds of Canadian owls which are suspected to be in Texas and Mexico. CWS has been working to raise awareness of the endangered status of Canadian Burrowing Owls and encourage participation in monitoring activities among biologists, birding organizations and HAM radio operators.

In December 1997, a wildlife reserve manager photographed a Burrowing Owl with Saskatchewan colour bands on a private ranch 25 kilometers north of McAllen, Texas, near the lower Rio Grande. This observation was significant as it constituted the first winter band recovery of a Canadian Burrowing Owl. The band combination revealed the owl was banded as an adult male in 1996 near Lang, Saskatchewan.

In November 1997, CWS conducted aerial surveys in Texas and detected a possible transmitter frequency near San Antonio. In December 1998, possible signals from two owls radio-tagged on the Regina Plain were detected 75 kilometers west of Corpus Christi and 45 kilometers south of the United States - Mexican border and 115 kilometers inland from the Gulf of Mexico. HAM Radio Operators are also involved in tracking transmitter frequencies and have established a web site (http://members.aol.com/joemoell/owl.html) to encourage member participation in monitoring activities.

All four (winter) records are on the coastal lowlands of the Gulf of Mexico which appears to be a major winter area for migrant owls. None remain there in the summer. Land use in areas where owls were located was dominated by intensive crop production. Investigations will continue to learn more about winter habitats, diets and factors which may be responsible for the population decline during the non-breeding season.

Table 7. Causes and rates of juvenile mortality in 1997 and 1998.

Year	Number of Dead Owls	Cause of Death	Mortality Rate
1997	0		0 per cent (0 of 12)
1998	8	Predation Hawks(7) Badger(1)	
	1	Road Kill	45 per cent
	2	Starvation	(15 of 33)
	2	Unknown	
	2	Other	

Captive/Release Project

In order to produce a workable protocol for release procedures, captive-born Burrowing Owls were released on the Regina Plain in 1997 and 1998. In 1997, 16 one-year-old Burrowing Owls raised in captivity (The Owl Foundation, Ontario and Alberta Birds of Prey Center) were paired together and placed in release cages. Cages were placed over an artificial nest burrow in suitable Burrowing Owl habitat. After three days in the cage, with daily supplemental feeding, each cage was removed and the owls set free. Three of the eight pairs remained together and successfully raised a brood of young, two females paired with wild males and raised broods and the remaining birds were not located after their release. Although the release birds successfully bred in the wild, their young did not survive as well as the young from natural owl pairs. One adult male was recovered in November in Moose Jaw. Having failed to migrate, this bird was near death. No adults or their young returned to the study area in 1998.

In 1998, 12 one-year-old Burrowing Owls were released on the Regina Plain. In this year, the owls' sex was surgically determined before pairing to ensure one female and one male per cage. Even so, none of the six pairs remained together, but four of the individuals (three females, one male) successfully produced young with wild birds. One of the males was killed by a hawk shortly after release, another male was found inside the nest of a wild pair of owls, one female remained single and the other birds were not relocated. Once again, two males were found late in the year, apparently not attempting to migrate. This may suggest Burrowing Owls that do not migrate in their first winter may not be capable of migrating in subsequent years.

Interestingly, none of the wild birds that mated with the release birds were previously known to be in the area. This might suggest there were "floaters" in many areas and they were not being detected during routine searches.

Conclusions

Results from the supplemental feeding research, conducted as part of the Productivity Project, demonstrate that food availability limits Burrowing Owl productivity. The 1998 population increase of Burrowing Owls in response to the 1997 vole outbreak certainly suggests that prey abundance on a large geographic scale can limit the population size of owls. Voles and other key prey species require undisturbed, thickly vegetated areas. Management practices that enhance foraging habitat for small mammals in the vicinity of Burrowing Owl nest sites may expedite recovery efforts by contributing to increased productivity, and potentially increasing the overall fitness of adult and juvenile owls prior to migration and providing an alternate prey source for Burrowing Owl predators. Increasing the amount of nesting habitat available to owls may reduce problems associated with habitat fragmentation including juvenile dispersal, potentially high predation rates and the ability of owls to find mates in fragmented landscapes.

The low return rates of banded owls suggests high overwinter mortality, especially for hatch-year owls, or that banded owls are not returning to our study area to breed in subsequent years. The increased number of returning unbanded owls in 1998 suggests immigration may be vital to maintaining stable populations. Expanding banding and search efforts in Saskatchewan and neighboring jurisdictions would contribute to a better understanding of how breeding and natal dispersal affect Burrowing Owl populations. Banding more birds may also result in more recoveries and sightings of banded birds along the migration route and in the wintering grounds and contribute to our understanding of overwinter mortality and habitats used during the non-breeding season.

International co-operation and involvement from the United States and Mexico is required to fully address Burrowing Owl conservation and recovery. Identification of the migratory route and the wintering grounds is a prerequisite to determining mortality factors associated with them and developing cooperative management strategies that may help to address the decline of Burrowing Owls in Canada.

Data on releasing captive-raised Burrowing Owls suggests owls that do not migrate in their first winter may not be capable of migrating in subsequent years. Releasing captive-raised, one-year old owls was deemed to be ineffective as a potential recovery strategy.

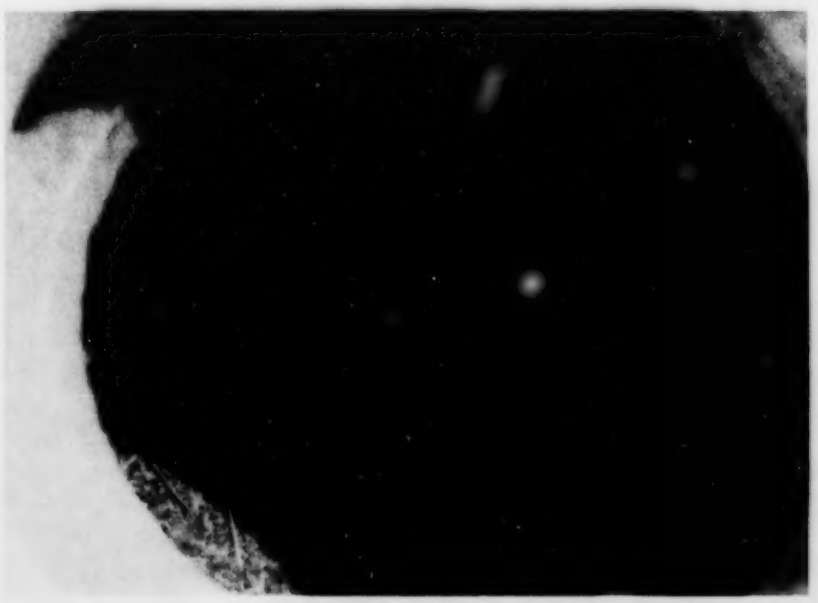
Nature Saskatchewan's OBO Program has been effective in encouraging the conservation of over 50,000 acres of Burrowing Owl nesting habitat through voluntary landowner stewardship. The OBO Program along with other initiatives such as the Saskatchewan Wetland Conservation Corporation's (SWCC) Native Prairie Stewardship Program, Saskatchewan Environment and Resource Management's (SERM) Representative Areas Network Program, the Prairie Conservation Action Plan and The Conservation Easement Act are advancing grassland conservation and management issues.

Saskatchewan's Burrowing Owl Recovery Project has provided invaluable information on factors affecting Burrowing Owl productivity and made it possible for us to conduct research studies on male foraging, the identification of the migratory route and the wintering grounds used by Canadian owls and release protocols for captive-raised owls. Research conducted under the Recovery Project facilitated long-term monitoring of the Regina Plain Burrowing Owl population and contributed significantly to an enhanced understanding of the natural history of this species. The Recovery Project was made possible through a partnership involving industry, government agencies, federal job placement programs for biologists and students, non-government conservation organizations, universities and landowners. Multi-stakeholder partnerships will be required to advance future recovery efforts for Burrowing Owls and other species at risk in the future.

Future Research Activities

In 1999 and 2000, research on Burrowing Owls in prairie Canada will continue in the Regina Plain and in the Eastern Irrigation District (E.I.D.) near Brooks, Alberta. These two areas will allow for interesting comparisons between owls residing in an area of dramatic and constant decline (Regina Plain) and owls living in an area that maintains a relatively stable population (E.I.D.). Danielle Todd (M.Sc. Student, University of Regina) will continue her research on post-fledging ecology of Burrowing Owls in the Regina Plain. In addition to gathering more information about the causes of mortality and patterns of dispersal of fledgling owls, this work will also include the continuation of supplemental feeding and the installation of artificial nest boxes. Darcey Shyry (M.Sc. Student, University of Alberta) will be conducting research identical to Danielle's in the E.I.D. Robert Sissons (M.Sc. Student, University of Alberta) will continue his work in the E.I.D. using radio telemetry to determine the nocturnal foraging behaviour and foraging habitat requirements of adult owls. Ray Poulin (Ph.D. Student, University of Regina) is conducting a habitat study on small mammals (important prey for Burrowing Owls) in southern Saskatchewan. Troy Wellicome (Ph.D. Student, University of Alberta) is completing his thesis on Burrowing Owl Productivity in the Regina Plain and working with the Canadian Wildlife Service (CWS) on publication of the proceedings of the 2nd International Burrowing Owl Symposium and on coordinating the 1st North American Burrowing Owl Census in 2001. The Census will provide valuable insight into the status of Burrowing Owls across the continent and encourage applied conservation and research efforts to benefit the species. Census methodology (using taped playback calls along survey routes) will be refined in 2000 in preparation for the Census. CWS will continue to work in Texas and Mexico to determine areas used by Canadian Burrowing Owls during the winter and investigate factors which contribute to population declines.

The Saskatchewan Burrowing Owl Interpretive Centre (SBOIC) in Moose Jaw will be expanded to provide year-round educational and ecotourism programming by housing and breeding captive-bred and injured owls indoors. The Interpretive Centre, SERM and other research partners will evaluate the effectiveness of fostering captive-raised chicks into the nests of wild owls as a potential recovery strategy.



Recommendations

- Continue the existing multi-stakeholder partnership to maintain recovery efforts on Burrowing Owls and initiate new partnerships to advance recovery efforts for other species at risk. Wildlife Preservation Trust Canada (WPTC), in partnership with Nature Saskatchewan, will lead future fundraising initiatives.

- Continue monitoring the Regina Plain Burrowing Owl population. To be conducted in conjunction with the Post-Fledging Ecology Research Study. Partial funding secured by WPTC. Additional funding required.

- Compare the Regina Plain Burrowing Owl population to the population outside of the Regina Plain which is monitored by the OBO program. Partial funding has been secured by Nature Saskatchewan. Additional funding required.

- Continue Post-Fledging Ecology Research on the Regina Plain, Saskatchewan and in the Eastern Irrigation District, Alberta study areas. WPTC funding confirmed for 2000.

- Create additional habitat for Burrowing Owls and key prey species in the Regina Plain. Nature Saskatchewan is working in partnership with SWCC's Native Prairie Stewardship Program on seeking funding support to help landowners restore and enhance nesting and foraging habitat.

- Continue research on land management practices and grazing regimes that contribute to enhanced small mammal populations to provide prey for Burrowing Owls and an alternate food source for Burrowing Owl predators. Additional funding required (R. Poulin (University of Regina-Ph.D. research study). Partial funding from WPTC has been secured.

- Expand banding search effort for banded birds in Saskatchewan and neighboring jurisdictions to facilitate a better understanding of how breeding and natal dispersal affect burrowing owl populations and to enhance knowledge of the migration route and wintering areas through band recoveries and sightings of banded birds. Funding required.

- Conduct research on the effects of habitat fragmentation and alternate prey sources on Burrowing Owl predation. Funding required.

- Conduct research to determine the impact of vehicle collisions and to identify and evaluate strategies which may be effective in reducing mortalities. Nature Saskatchewan is evaluating the effectiveness of their Road Warning Sign Program in reducing vehicle collisions near nesting areas where landowners have requested signs.

- Continue and strengthen efforts aimed at determining the migratory route and the wintering grounds of Canadian Burrowing Owls and factors responsible for population declines in these areas. Additional funding would strengthen CWSs efforts to determine the wintering grounds and conduct research in these areas.

- Continue research on protocols for release procedures using captive-raised Burrowing Owls. Conduct research studies on fostering (placing captive-raised chicks with wild broods) and hacking (releasing captive-raised juvenile owls) to determine their effectiveness as potential recovery strategies should they be required in the future conservation of the species. Partial funding has been secured by WPTC. Additional funding required.